US009182191B2

(12) **United States Patent**
Gardner, Jr. et al.

(10) **Patent No.: US 9,182,191 B2**
(45) **Date of Patent: Nov. 10, 2015**

(54) **PNEUMATIC GUN HAVING MECHANICALLY-ACTUATED PNEUMATIC VALVE**

(71) Applicant: **GOG Paintball, S.A.**, Plaza Roble Escazu (CR)

(72) Inventors: **William M Gardner, Jr.**, Loyalhanna, PA (US); **Hans Semelsberger**, Loyalhanna, PA (US); **Richard D Galinson**, Toluca Lake, CA (US)

(73) Assignee: **GOG Paintball, S.A.**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/046,263**

(22) Filed: **Oct. 4, 2013**

(65) **Prior Publication Data**

US 2014/0096758 A1 Apr. 10, 2014

Related U.S. Application Data

(60) Provisional application No. 61/710,106, filed on Oct. 5, 2012.

(51) **Int. Cl.**

F41B 11/723	(2013.01)
F41B 11/72	(2013.01)
F41B 11/70	(2013.01)
F41B 11/721	(2013.01)

(52) **U.S. Cl.**

CPC ***F41B 11/72*** (2013.01); ***F41B 11/70*** (2013.01); ***F41B 11/721*** (2013.01); *F41B 11/723* (2013.01)

(58) **Field of Classification Search**

CPC F41B 11/72; F41B 11/62; F41B 11/73; F41B 11/721; F41B 11/68; F41B 11/722; F41B 11/724; F41B 9/0037; F41B 11/723; F41B 11/70; F41B 11/71; F41B 11/64

USPC 124/73, 71, 72, 75, 76

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,613,483	A *	3/1997	Lukas et al.	124/73
D533,908	S	12/2006	Jones	
D535,709	S	1/2007	Jones	
D544,928	S	6/2007	Jones	
D546,297	S	7/2007	Jones	
D548,201	S	8/2007	Jones	
D554,204	S	10/2007	Stossell	
D571,415	S	6/2008	Jones	

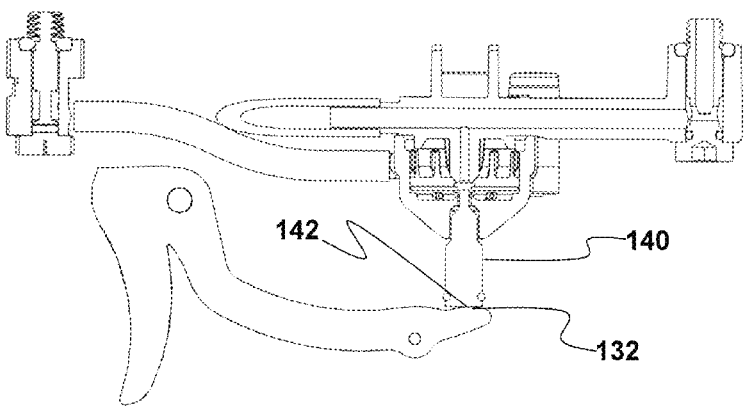
(Continued)

Primary Examiner — Samir Abdosh
Assistant Examiner — John D Cooper
(74) *Attorney, Agent, or Firm* — Craig R. Rogers; SIMPLE IP Law, P.C.

(57) **ABSTRACT**

According to principles of the present inventive concepts, a mechanically-actuated pneumatic valve can comprise an input port receiving compressed gas from a compressed gas regulator and one or more output ports. A face seal can be arranged in the valve body and be configured to move between two positions. In a first position, the face seal can permit compressed gas from the input port to be supplied to a first output port. In a second position, the face seal can vent compressed gas from the valve body through an exhaust port. An actuator, such as a pin or pin-shaped actuator, for example, can be configured and arranged to move the face seal from the first position to the second position, such as during a trigger pull. A contact surface could be configured to physically contact a surface of the pin-shaped actuator (either directly from the trigger or through one or more other components or mechanisms) and drive the face seal to its second position during actuation of the trigger.

20 Claims, 20 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,461,646	B2	12/2008	Jones	
7,556,032	B2	7/2009	Jones et al.	
7,617,820	B2	11/2009	Jones	
7,624,723	B2	12/2009	Gardner et al.	
2006/0207587	A1	9/2006	Jones et al.	
2011/0017188	A1*	1/2011	Call	124/73
2011/0232618	A1*	9/2011	Gabrel	124/73

* cited by examiner

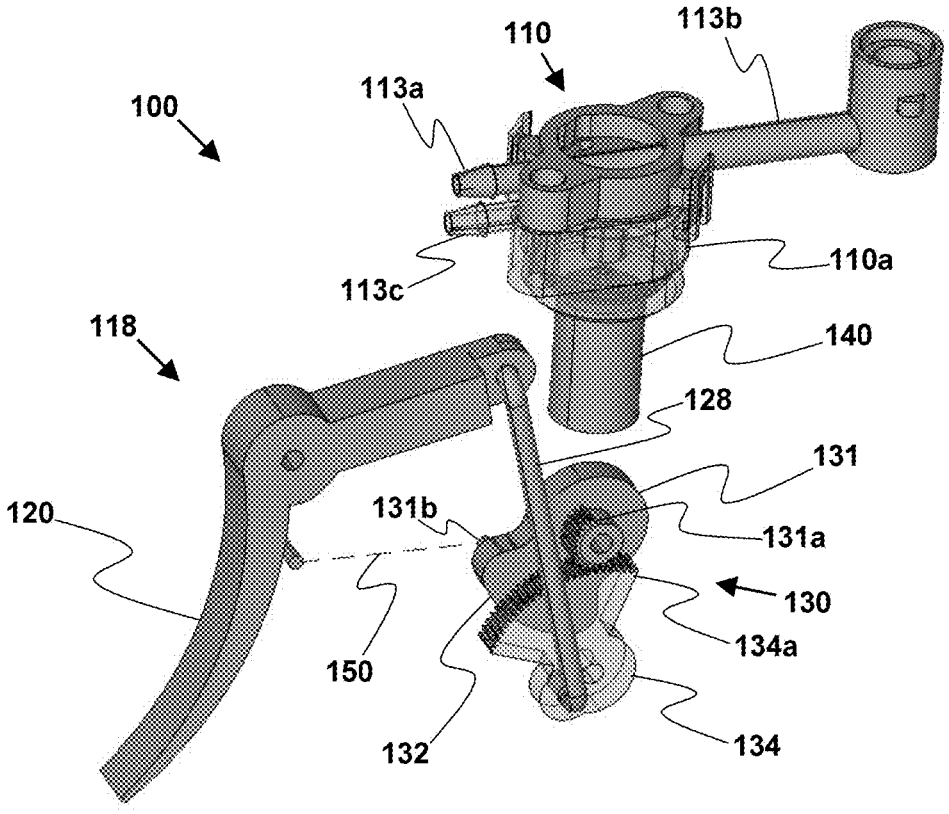

100
110
113a
113b
110a
113c
118
140
128
131
120
131b
131a
130
134a
150
132
134

FIG. 1

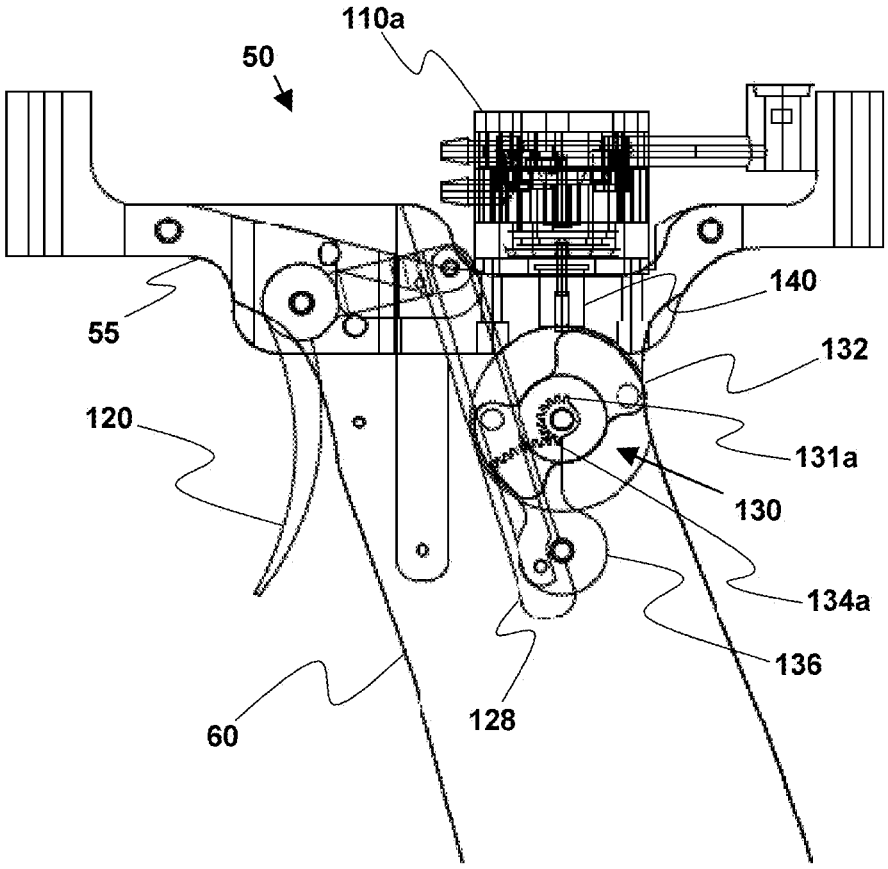


FIG. 2

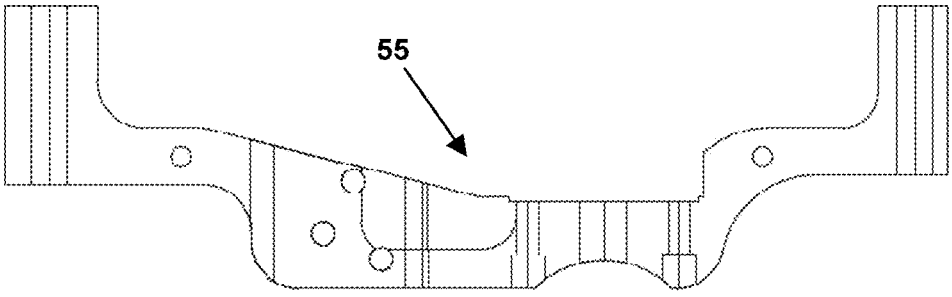


FIG. 3

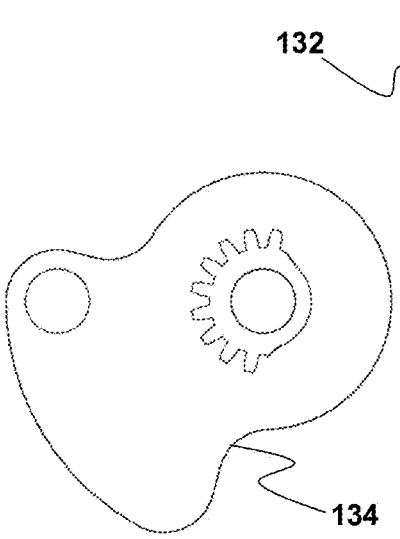


FIG. 4

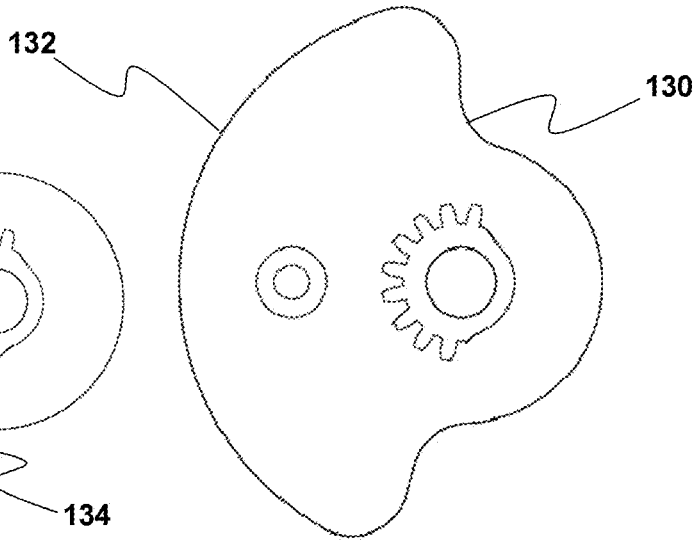


FIG. 5

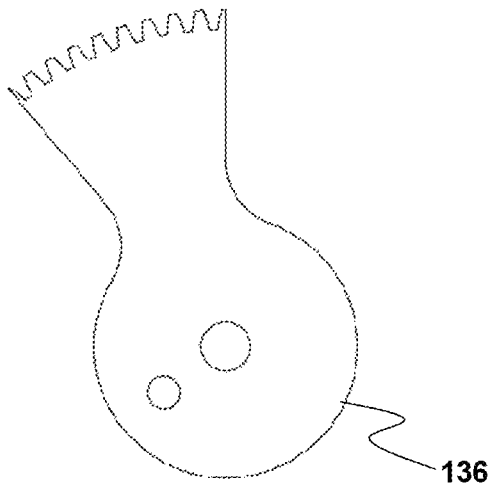


FIG. 6

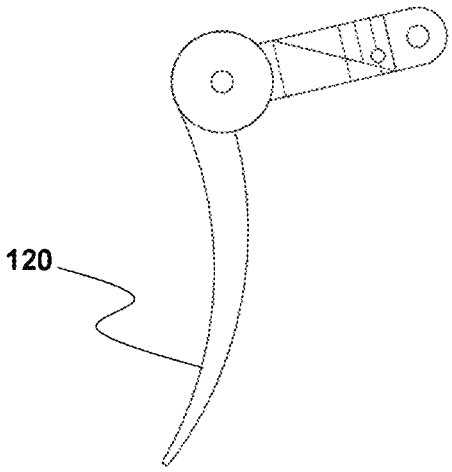


FIG. 7

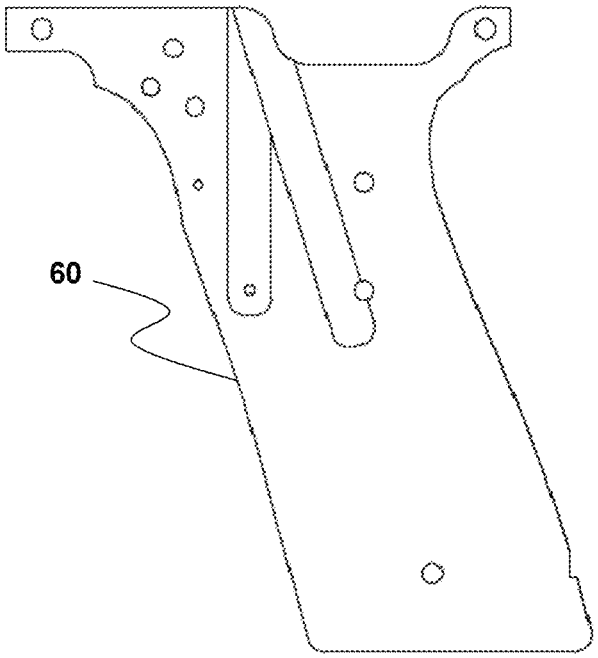


FIG. 8

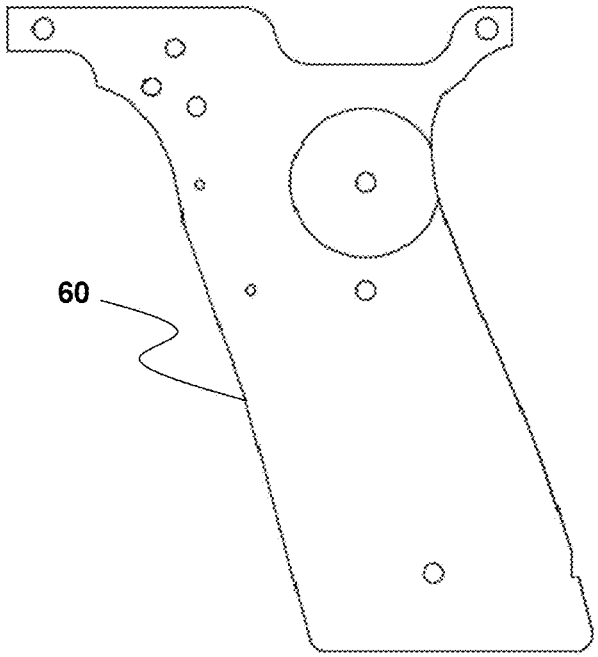


FIG. 9

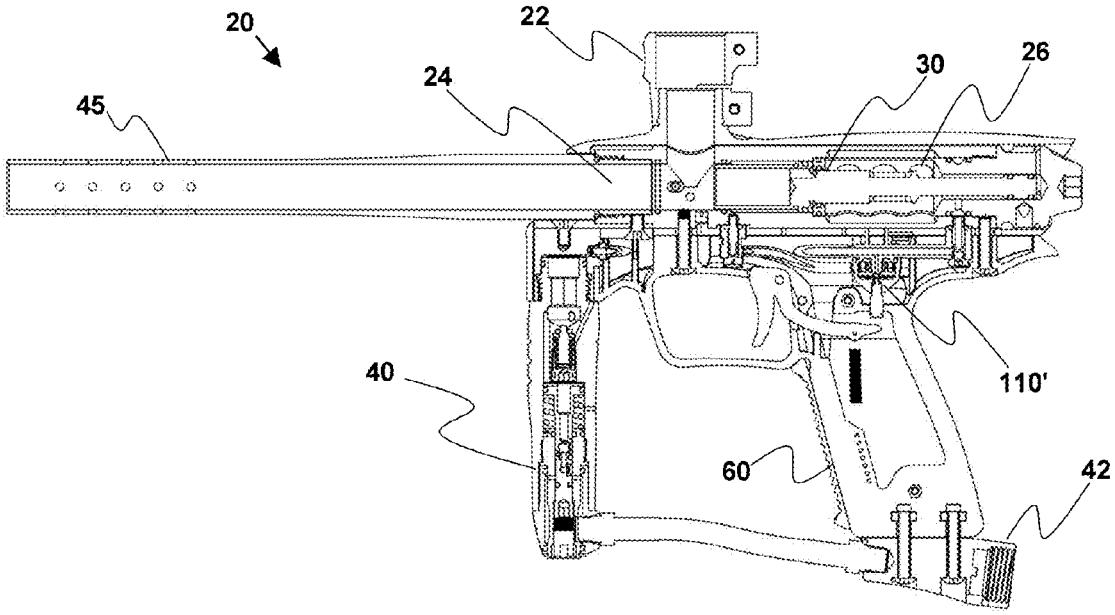


FIG. 10

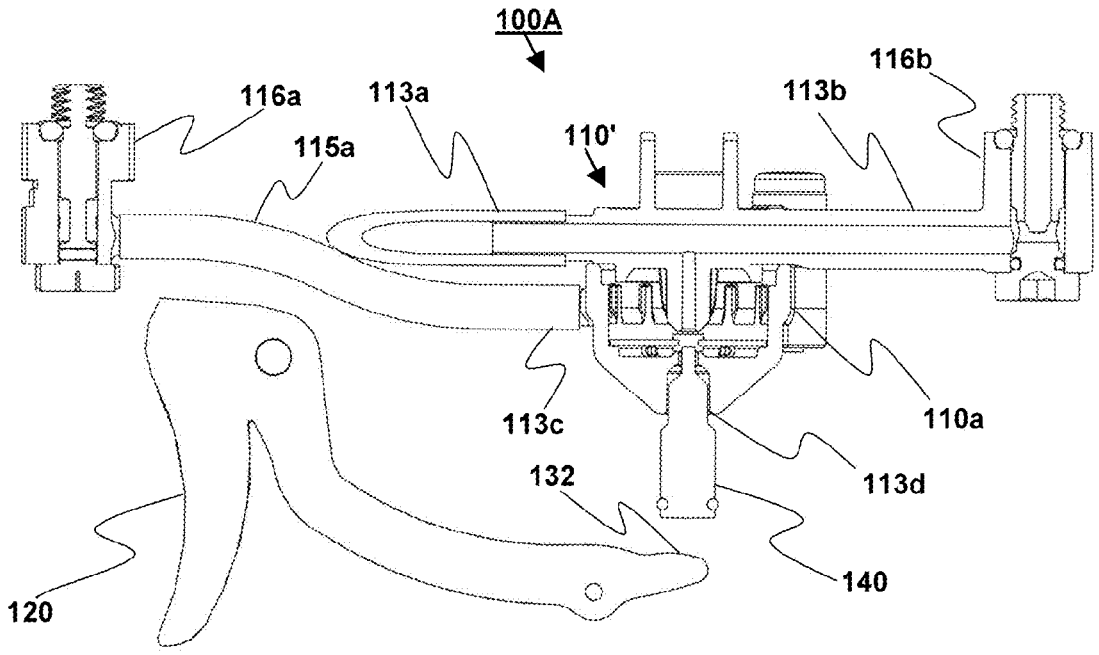


FIG. 11

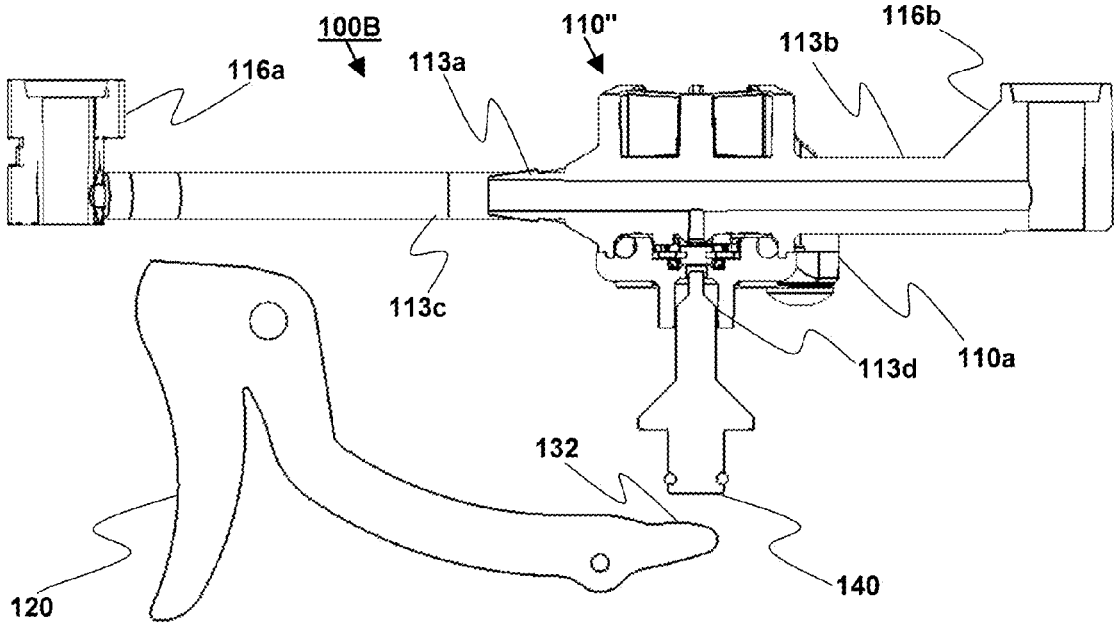


FIG. 11A

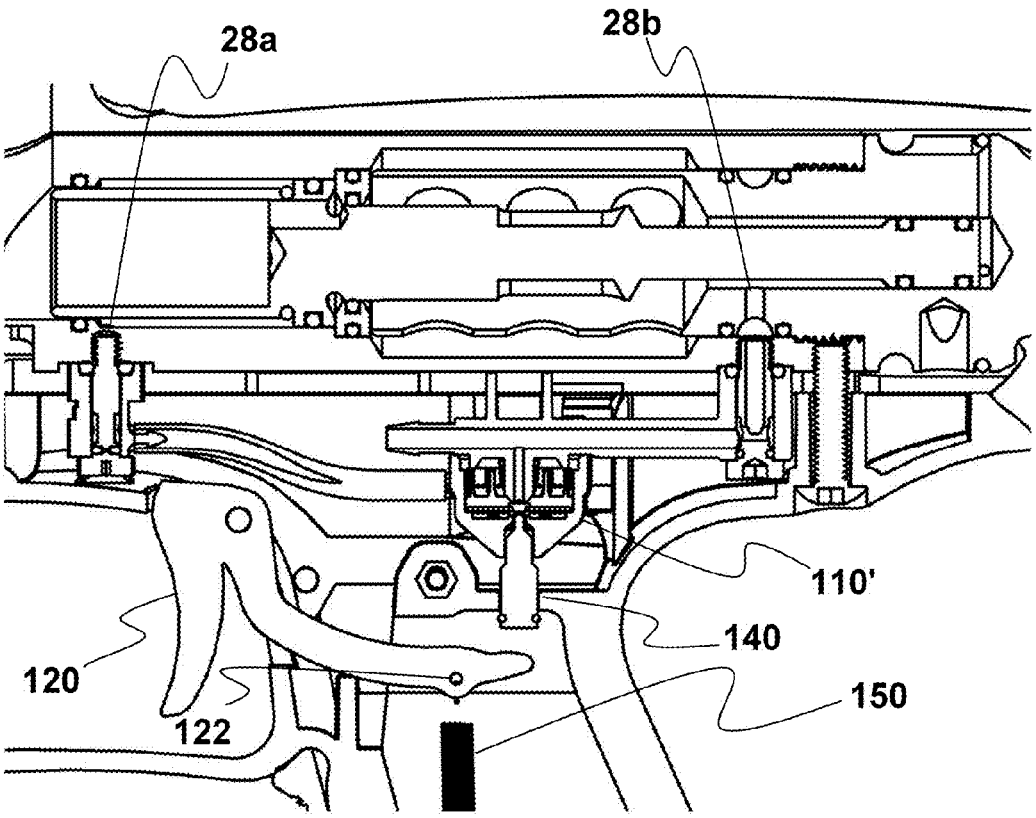


FIG. 12

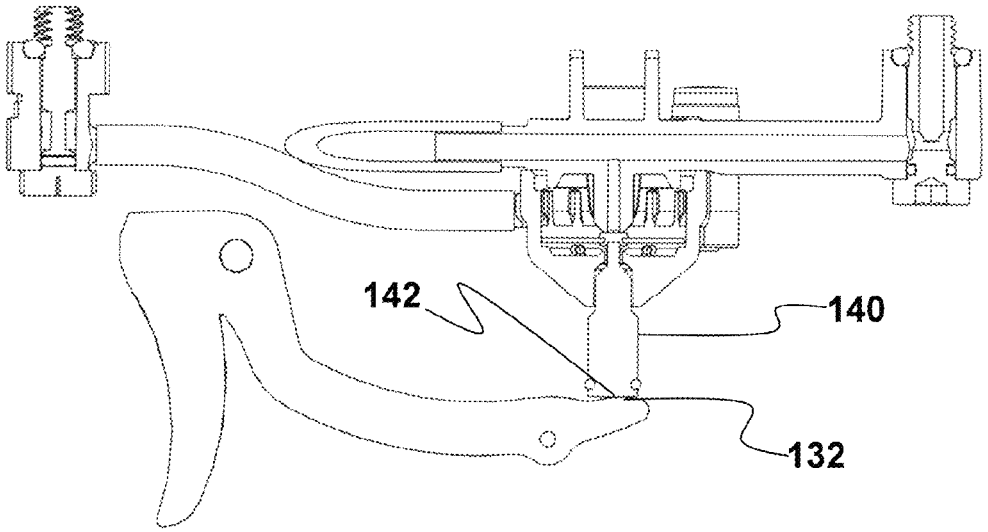

142
140
132

FIG. 13

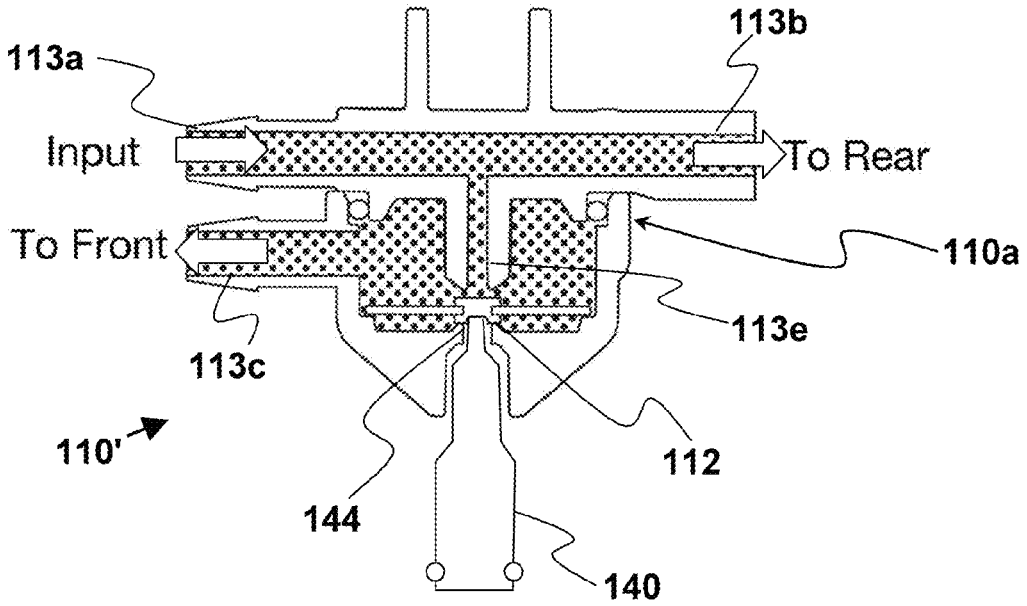

113a
113b
Input
To Rear
To Front
110a
113e
113c
110'
112
144
140

FIG. 14

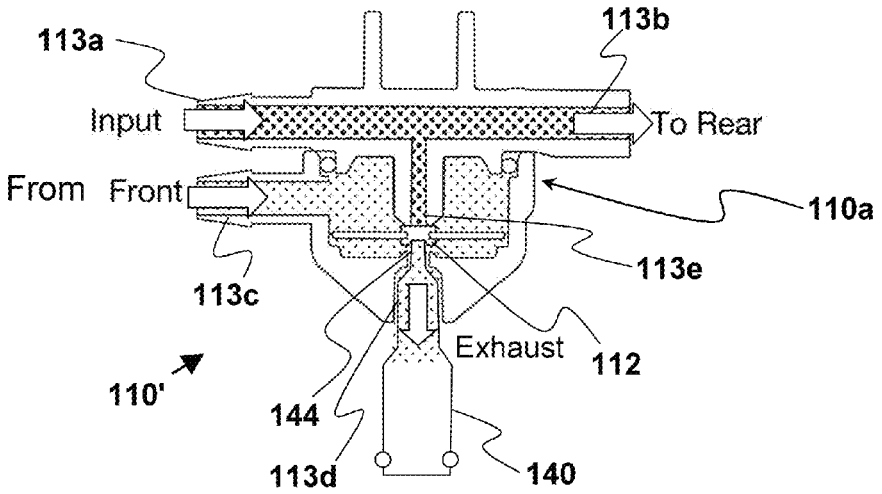

113a
113b
Input
To Rear
From Front
110a
113e
113c
Exhaust
112
110'
144
113d
140

FIG. 15

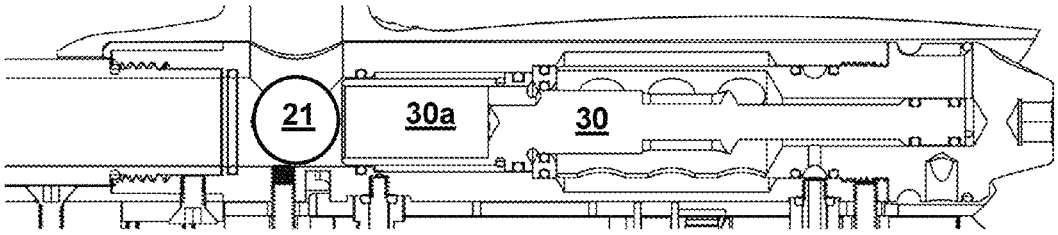

21
30a
30

FIG. 16

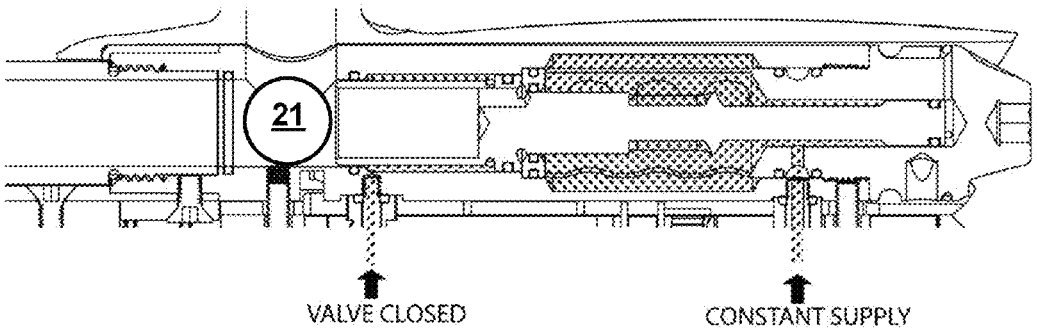


FIG. 17A

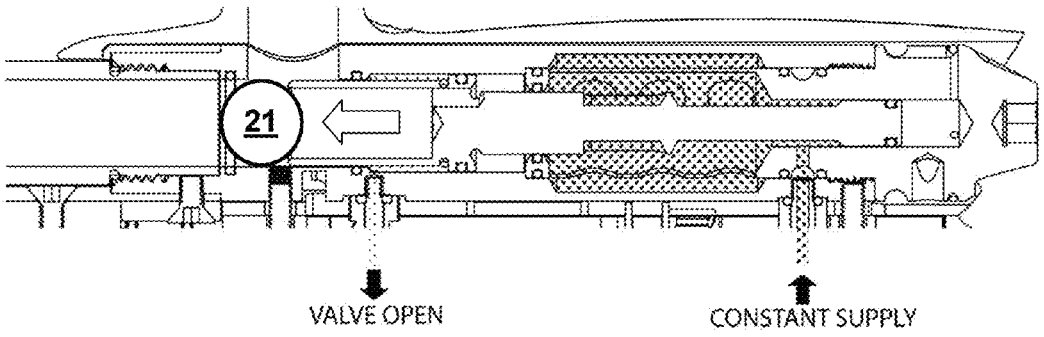


FIG. 17B

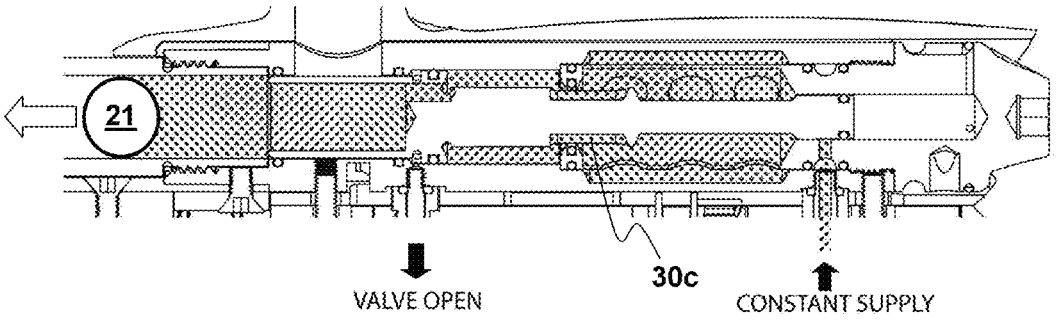


FIG. 17C

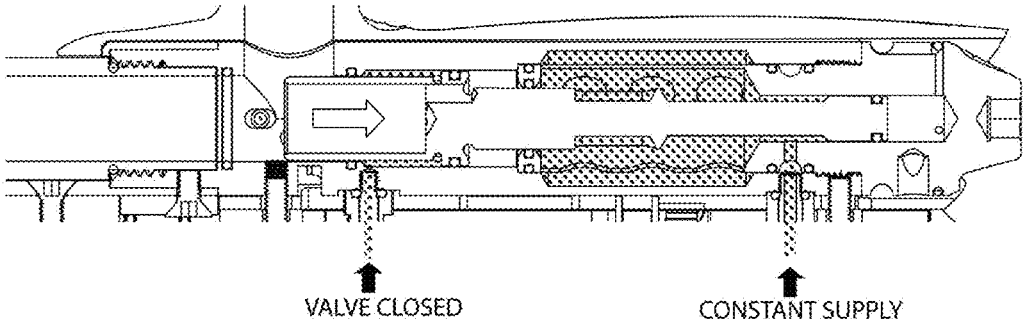


FIG. 17D

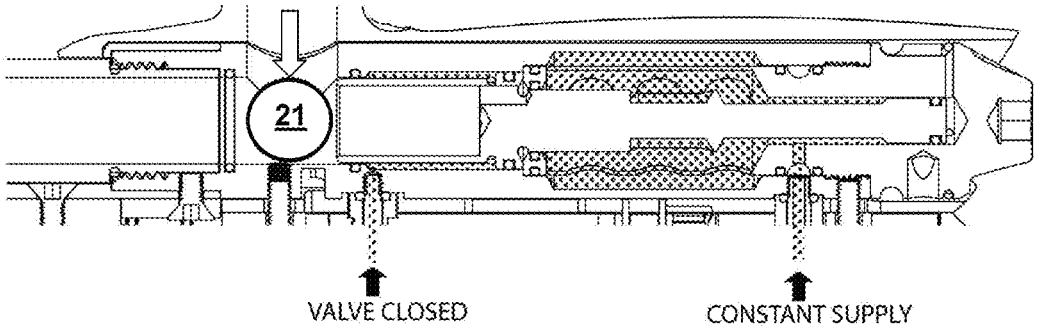


FIG. 17E

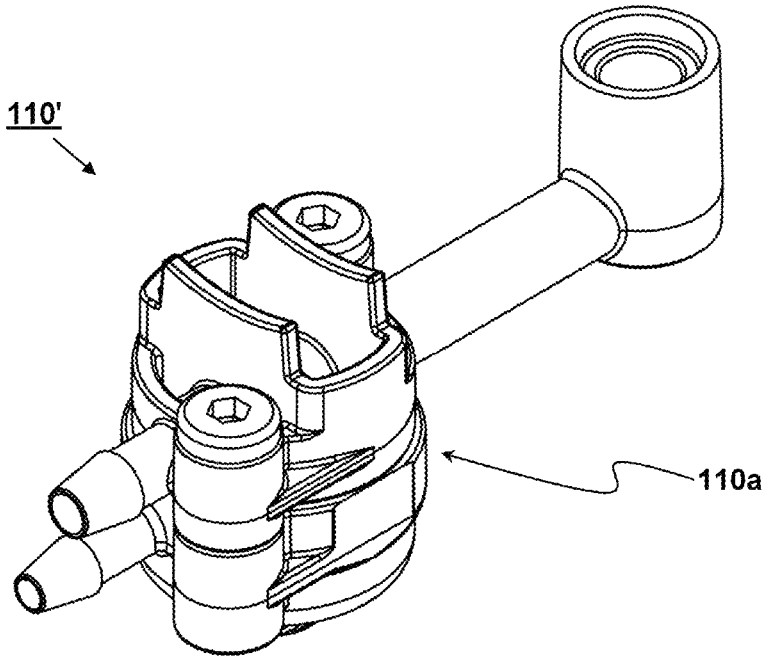


FIG. 18

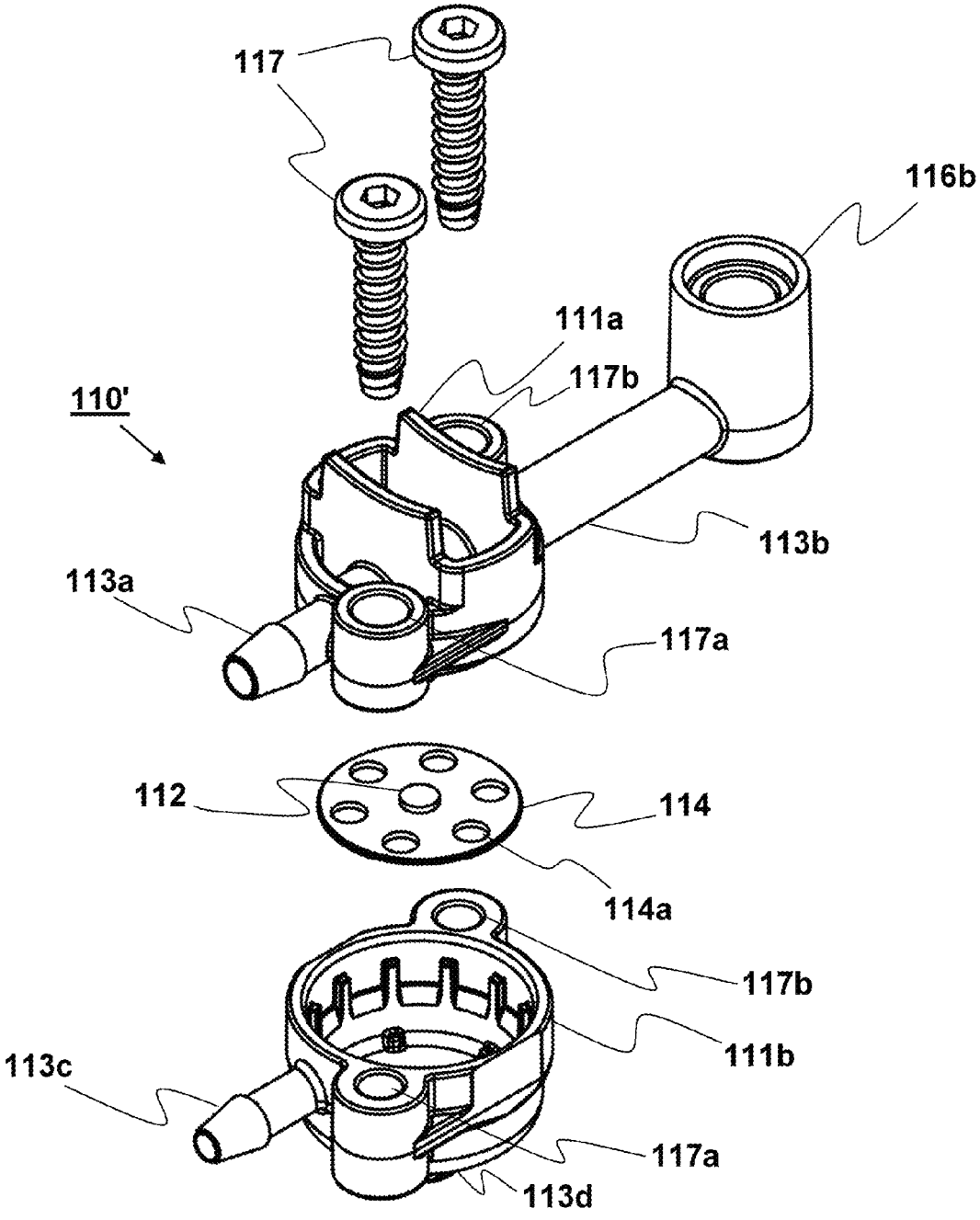

117
116b
111a
117b
110'
113b
113a
117a
112
114
114a
117b
111b
113c
117a
113d

FIG. 18A

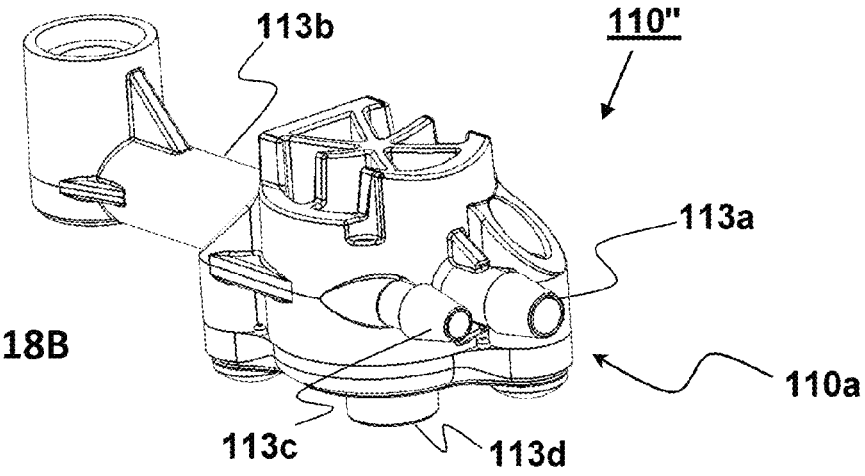


FIG. 18B

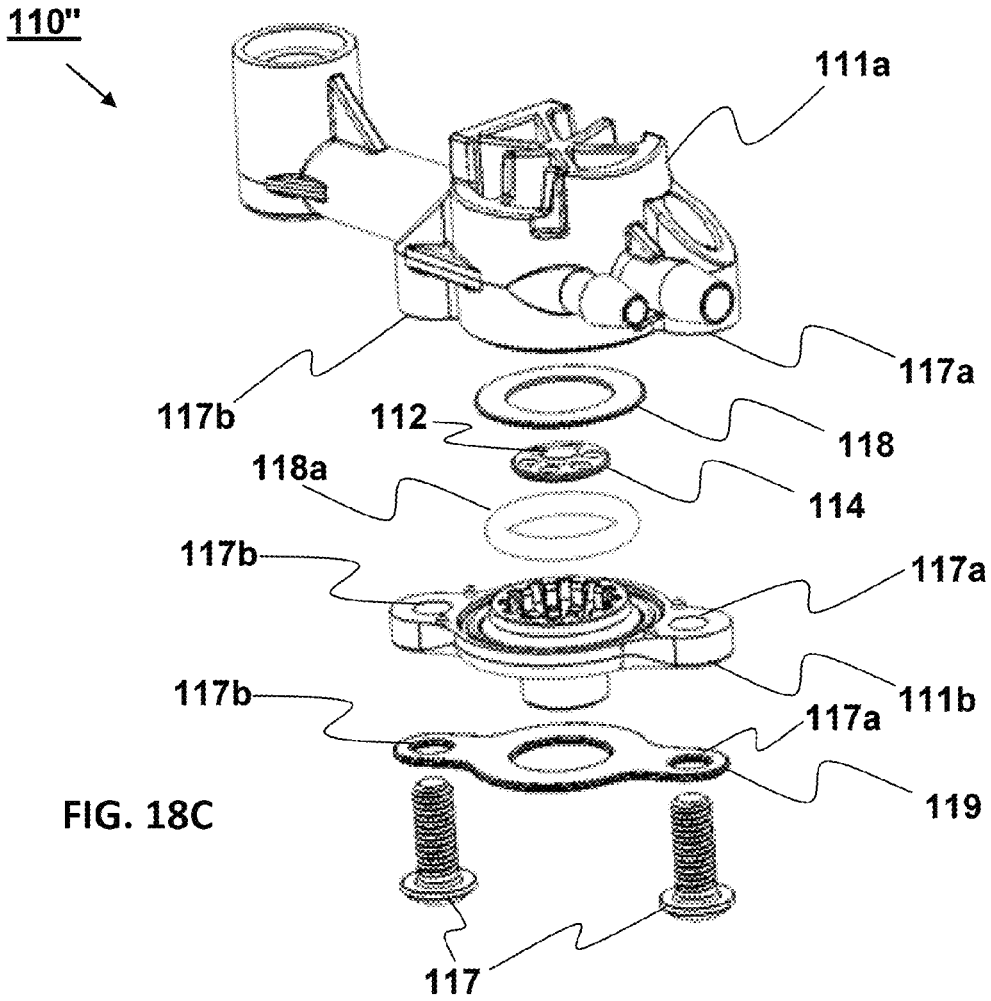


FIG. 18C

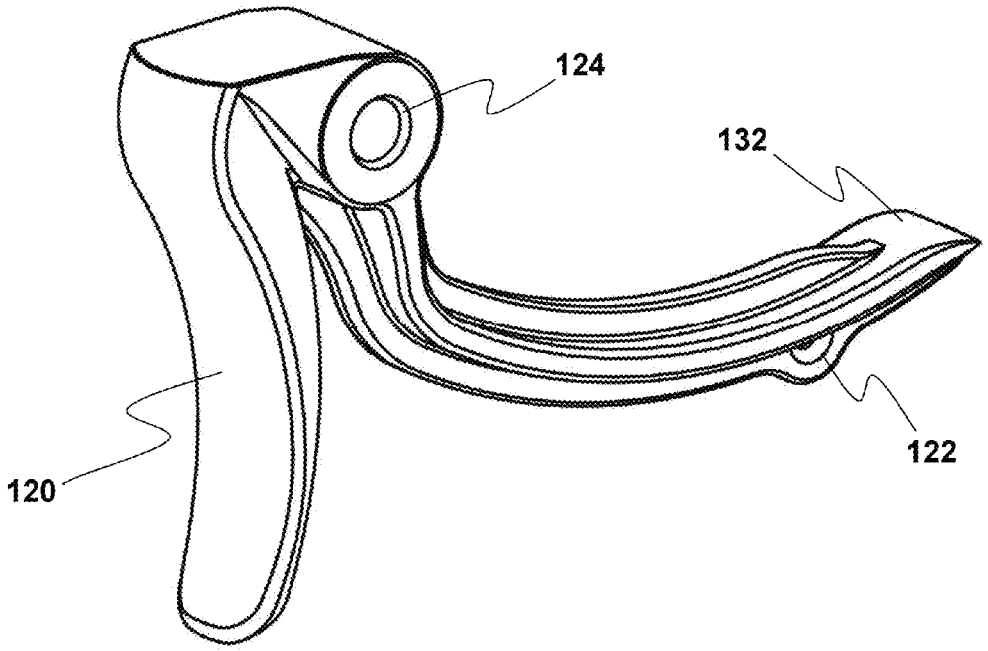


FIG. 19

PNEUMATIC GUN HAVING MECHANICALLY-ACTUATED PNEUMATIC VALVE

PRIORITY CLAIM

This application claims priority from U.S. Provisional Patent Application Ser. No. 61/710,106, filed Oct. 5, 2012; Chinese Patent Application Serial No. 201210589028.4, filed Dec. 31, 2012; and Taiwanese Patent Application Serial No. 102119605, filed Jun. 3, 2013; the contents of each of which are hereby incorporated herein by reference in their entirety.

BACKGROUND

1. Field of the Inventive Concepts

The present inventive concepts relate generally to pneumatic guns. More particularly, these inventive concepts relate to a pneumatic gun that provides a number of advancements over the prior art.

2. Related Art

Electronically-operated pneumatic guns have become ubiquitous in tournament and recreational paintball game play and have also found applications in other fields and industries. For instance, pneumatic guns can be used as remote delivery applicators for veterinary medicines, pesticides, insecticides, etc. In paintball particularly, electronically-operated spool-valve designs are extremely popular among players because of their relatively light weight, reliability, low-pressure operation, and ease of maintenance. One such electronically-operated paintball gun having a spool-valve design is shown and described in U.S. Pat. No. 7,617,820 ("the '820 patent"), the contents of which are hereby incorporated by reference in their entirety.

Unfortunately, however, prior to the present inventive concepts, there has not been a reliable mechanism for mechanically-operating pneumatic guns having this and other types of spool-valve designs.

SUMMARY

According to various embodiments and principles of the present inventive concepts, a mechanical pneumatic gun can provide numerous improvements over the prior art, including, for instance, a mechanically-operated trigger and valve assembly that can be used to drive a pneumatic assembly similar to that used in an electronic paintball gun.

According to one aspect of the present inventive concepts, a mechanically-operated trigger assembly for a pneumatic gun includes a trigger, a cam actuator, and a return mechanism. According to this aspect, the trigger causes the cam actuator to pivot into contact with a valve actuator for initiating a firing operation of the pneumatic gun. The trigger can interact with the cam actuator, for instance, through a geared interconnection, a geneva mechanism, or other suitable connection. The cam actuator can be configured to contact the valve actuator for a sufficient period of time (dwell) during each trigger pull to permit the valve to release a sufficient quantity of compressed gas to initiate a full firing cycle of the pneumatic gun. This can be accomplished, for instance, by configuring a contacting surface of the cam actuator with a sufficient surface area to contact the valve actuator for a sufficient length of time during each trigger pull.

The return mechanism can comprise, for instance, one or more springs or one or more magnets arranged to cause the cam mechanism to rotate sufficiently after each trigger pull to return to its ready position. For instance, the return mechanism can be a spring assembly configured to pull the cam mechanism around from the actuating position to a start position where the geared cam surface reengages with the geared trigger interconnection. Alternatively, or additionally, reverse polarity magnets can be used to apply a force that encourages the cam assembly to rotate from the firing position back to the ready position.

According to another aspect of the present inventive concepts, a mechanically-actuated pneumatic valve can comprise a valve body having an input port receiving compressed gas from a compressed gas regulator and one or more output ports. A face seal can be arranged in the valve body and be configured to move between two positions. In a first position, the face seal can permit compressed gas from the input port to be supplied to a first output port. In a second position, the face seal can vent compressed gas from the valve body through an exhaust port. An actuator, such as a pin or pin-shaped actuator, for example, can be configured and arranged to move the face seal from the first position to the second position, such as during a trigger pull. A contact surface of a trigger, for instance, could be configured to contact a surface of the pin-shaped actuator (either directly or through one or more other components or mechanisms) and drive the face seal to its second position during actuation of the trigger.

In one pneumatic gun embodiment, compressed gas having a selected pressure can be supplied from the compressed gas regulator to a compressed gas storage chamber of the pneumatic gun. The pneumatic valve can be configured to supply compressed gas of the selected pressure from the compressed gas regulator to a first surface of a spool-valve piston through the first output port when the face seal is arranged in its first, deactuated position. The compressed gas acting on the first surface of the spool-valve piston can overcome a pneumatic or spring force acting on a second surface of the spool-valve piston.

In one embodiment, the spool-valve piston can comprise a bolt and a firing valve. The first surface can be a forward surface and the pneumatic force acting on the first surface can hold the bolt in a rearward position against a pneumatic force from the compressed gas storage chamber acting on the second piston surface area.

In one embodiment, a trigger can be configured with a contact surface or actuator arranged to contact a valve actuator or valve pin of the pneumatic valve (either directly or through one or more components or mechanisms). When the trigger is pulled, its contact surface or actuator contacts the valve actuator or pin to move the face seal from its first position to its second position. In the second position, compressed gas is prevented from being supplied to the first output port from the compressed gas regulator, and gas from the first output port is instead vented through an exhaust port arranged in the valve body or elsewhere.

When the first output port communicates with the forward piston surface, gas is then vented from an area communicating with the forward piston surface and a force on the second, rearward piston surface drives the bolt forward and opens the firing valve. The bolt is thereby positioned into its forward, firing position and compressed gas from the compressed gas storage chamber vents through the firing valve and through ports arranged in the bolt to launch a projectile from the gun.

The firing valve can, for instance, comprise one or more surfaces of the bolt configured to communicate with one or more seals to retain gas in the compressed gas storage area until a firing operation is performed. During a firing operation, the bolt surface(s) and seal(s) can be configured to release the compressed gas from the compressed gas storage

area through the bolt and into contact with a paintball arranged in a breech of the paintball gun.

In one embodiment, the distance the face seal travels from its first position to its second position is less than approximately 0.015 inches, and can be less than about 0.0075 inches. This short travel distance permits the valve to be actuated through a relatively short trigger pull. Using a mechanically-actuated face seal valve design thereby overcomes numerous problems encountered in the related art. Other mechanical, pneumatic designs for instance used radial seals in the actuation valve and therefore required much longer trigger pulls. Longer trigger pulls often result in misfires or misfeeds when an operator fails to fully pull or fully release the trigger during operation.

Other conventional mechanical valve designs further typically require lubrication of the moving pins, shafts or other components that control the flow of gas through the valves. A mechanical face seal design according to principles of the present inventive concepts can further eliminate lubrication requirements for the moving components of the valve and significantly reduce maintenance issues associated with the pneumatic control valve. Using this design, the life of the valve can also therefore be significantly increased.

Various aspects, embodiments, and configurations of the inventive concepts are possible without departing from the principles disclosed herein. The inventive concepts are therefore not limited to any of the particular aspects, embodiments, or configurations described herein.

BRIEF DESCRIPTION OF DRAWINGS

The foregoing and additional objects, features, and advantages of the present inventive concepts will become more readily apparent from the following detailed description of preferred embodiments, made with reference to the attached drawings, in which:

FIG. **1** is a somewhat schematic, semi-transparent perspective view showing a trigger, cam and valve assembly removed from a pneumatic gun according to one embodiment incorporating principles of the present inventive concepts;

FIG. **2** is a somewhat schematic cross-sectional, semi-transparent side view of a grip frame assembly for a pneumatic gun having a trigger, cam and valve assembly according to additional principles of the present inventive concepts;

FIG. **3** is a somewhat schematic cross-sectional side view of an adapter mount for connecting the grip frame and mechanical trigger assembly of FIG. **2** to a conventional electro-pneumatic paintball gun;

FIGS. **4** and **5** are enlarged somewhat schematic side views of a cam and large cam, respectively, from the assembly of FIG. **2**;

FIG. **6** is an enlarged somewhat schematic side view of the driver gear of the assembly of FIG. **2**;

FIG. **7** is an enlarged somewhat schematic cross-sectional side view of the trigger of the assembly of FIG. **2**;

FIG. **8** is a somewhat schematic side view of the left side grip frame of the assembly of FIG. **2**;

FIG. **9** is a somewhat schematic side view of the right side grip frame of the assembly of FIG. **2**;

FIG. **10** is a somewhat schematic cross-sectional side view of a pneumatic gun having a trigger assembly and mechanically-actuated pneumatic valve, according to another embodiment incorporating features of the present inventive concepts;

FIG. **11** is a somewhat schematic cross-sectional exploded view showing the trigger and valve assembly removed from the pneumatic gun of FIG. **10**, along with its pneumatic connectors;

FIG. **11**A is a somewhat schematic cross-sectional exploded view showing a trigger and valve assembly according to another embodiment of the present inventive concepts;

FIG. **12** is a somewhat schematic cross-sectional close-up side view of the mechanically-actuated pneumatic valve and trigger assembly arranged in the pneumatic gun of FIG. **10**, illustrating the mechanical pneumatic valve in a deactuated position;

FIG. **13** is a somewhat schematic cross-sectional close-up side view of the mechanically-actuated pneumatic valve and trigger assembly of the pneumatic gun of FIG. **10**, illustrating the mechanical pneumatic valve in an actuated position;

FIG. **14** is a somewhat schematic cross-sectional side view of the mechanically-actuated pneumatic valve of FIG. **12**, illustrating a flow path of compressed gas through the pneumatic valve in its deactuated (closed) position;

FIG. **15** is a somewhat schematic cross-sectional side view of the mechanically-actuated pneumatic valve of FIG. **12**, illustrating a flow path of compressed gas through the pneumatic valve in its actuated (open) position;

FIG. **16** is a somewhat schematic cross-sectional side view illustrating pneumatic components of a pneumatic gun according to additional principles of the present inventive concepts;

FIGS. **17**A-**17**E are somewhat schematic cross-sectional side views of the pneumatic gun of FIG. **16**, illustrating the operation of a pneumatic gun constructed according to additional principles of the present inventive concepts;

FIG. **17**A illustrates a location of compressed gas and pneumatic components in the gun body during a normal, resting state, with the pneumatic gun ready to begin a firing operation;

FIG. **17**B illustrates the position of the compressed gas and pneumatic components during initiation of a firing operation of the pneumatic gun;

FIG. **17**C further illustrates the flow of compressed gas and positioning of pneumatic components during a firing operation of the pneumatic gun;

FIG. **17**D illustrates the supply of compressed gas through the pneumatic gun when initiating a loading operation of the pneumatic gun;

FIG. **17**E further illustrates the flow of compressed gas and positioning of pneumatic components during the loading operation;

FIGS. **18** and **18**A are a somewhat schematic perspective and exploded perspective views, respectively, of a mechanical pneumatic valve for use in the pneumatic gun of FIG. **10**, according to another aspect of the present inventive concepts;

FIGS. **18**B and **18**C are a somewhat schematic perspective and exploded perspective views, respectively, of a mechanical pneumatic valve for use in a pneumatic gun, according to yet another embodiment of the present inventive concepts; and

FIG. **19** is a somewhat schematic perspective view of a trigger for use in the pneumatic gun of FIG. **10**, according to yet another aspect of the present inventive concepts.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Various features, benefits, and configurations incorporating principles of the present inventive concepts in illustrative embodiments are shown and described in detail in the follow-

ing description and accompanying drawings. Additional features, benefits and configurations will be readily apparent to those of ordinary skill in the art based on this disclosure; and all such features, benefits and configurations are considered within the scope of the present inventive concepts.

Various illustrative embodiments will now be described in connection with the accompanying drawings. Referring initially to FIG. **1**, in one embodiment, parts of a trigger assembly **118** can, for instance, be made out of stamped or molded parts. A cam assembly **130**, in particular, can be made from two stamped parts that are pressed together. The design shown in FIG. **1** includes two cams **131** and **134** which include two mating partial gears **131***a*, **134***a* that can, for instance, be either molded or stamped, depending on how fine a gear tooth is desired. The sizes of the two gears **131***a*, **134***a* could be increased to accommodate production limitations as long as their relative ratios stay approximately constant. Alternative designs, such as geneva mechanisms or other interconnections between the trigger and cam assemblies are also possible.

Referring specifically to FIG. **1**, a mechanical trigger and valve assembly **100** is shown removed from a pneumatic gun. In FIG. **1**, the mechanism **100** is shown in its resting state or ready state. In this particular design, the trigger **120** is limited to a rotation angle of about 7 degrees. As the trigger **120** rotates, it pulls the lower cam **134** and therefore partial gear **134***a* thru roughly a 55 degree clockwise (CW) arc via the steel connecting rod **128**. The rotation of the lower gear **134***a* in turn rotates the upper partial gear **131***a* on the upper cam **131** in the counter-clockwise (CCW) direction through about 200 degrees of rotation, bringing the larger lobe (cam actuator) **132** of the cam up almost under the round piston (valve actuator) **140** of the pneumatic valve assembly **110**. As the upper cam **131** is rotated, an extension spring (shown as a dotted line **150**) is stretched.

When the gears disengage at about the 200 degree mark, the spring **150** is extended but the pin **131***b* connecting the spring **150** to the upper cam **131** is now in the over-center position. The spring **150** is therefore free to pull the upper cam **131** around the rest of the revolution, causing the contact surface of the cam actuator **132** to strike and actuate the valve actuator **140**. The cam actuator **132** is preferably designed and engineered to keep the armature plate (inside valve **110**) up for the correct time, thereby keeping the valve **110** open for the desired dwell time. The spring **150** preferably pulls the upper cam **131** all the way around to the starting position so the trigger **120** is ready for the next shot.

Of course, numerous variations to this specific design are possible. For instance, the size and numbers of teeth in the gears can be modified as desired to accomplish the purposes of the inventive concepts. The return force provided by the spring can be supplemented or replaced entirely by a magnetic force (e.g., provided by reverse polarity magnets appropriately situated within the assemblies). The gears may be eliminated altogether such as through use of a geneva mechanism or other design. A sear approach could be used to cock the cam against the spring tension, with the cam designed and configured not to contact with the valve piston as it is being pushed back to prevent opening the valve during the cocking portion of the trigger pull. One way to accomplish this, for example, is to offset the cam laterally during the cocking stage.

As mentioned earlier, one possible way of eliminating the gears is to use a geneva mechanism. A geneva mechanism is a gear mechanism that translates a continuous rotation into an intermittent rotary motion. The rotating drive wheel can include a pin that reaches into a slot of the driven wheel, advancing it by one step. The drive wheel also may include a raised circular blocking disc that locks the driven wheel in position between steps. In the most common arrangement, the driven wheel has four slots and thus advances for each rotation of the drive wheel by one step of 90°. If the driven wheel has n slots, it advances by 360°/n per full rotation of the drive wheel.

In a still further alternative embodiment, a small hammer and sear mechanism could be used to actuate the valve actuator. A spring-loaded hammer can be configured to strike a small mechanical valve pin or pin-shaped actuator. The mechanically-operated pneumatic valve could then be configured to operate the bolt and firing mechanisms to initiate loading and firing operations of the pneumatic gun. The valve assembly can be further configured to push the hammer back to a cocked position for the next shot.

As mentioned previously, electronically-operated pneumatic guns are commonplace in tournament and recreational paintball game play. One such electronically-operated paintball gun is shown and described in the '820 patent. The principles of the present inventive concepts provide, among other things, a mechanism for converting an electro-pneumatic paintball gun, such as that shown in the '820 patent, into a mechanically-operated pneumatic gun.

Referring now to FIGS. **2-9**, according to certain embodiments of the present inventive concepts, a mechanically-operated trigger assembly **118** is provided for a pneumatic gun. The trigger assembly preferably includes a trigger **120**, a cam actuator **132**, and a return mechanism **150** arranged in a grip frame **60** of the pneumatic gun. The trigger **120** can be configured to cause the cam actuator **132** to pivot into contact with a valve actuator **140** for initiating firing and loading operations of the pneumatic gun.

The trigger can interact with the cam actuator **132**, for instance, through a geared interconnection (as shown), a geneva mechanism (not shown), or other suitable mechanical connection. The cam actuator **132** is preferably configured to contact the valve actuator **140** for a sufficient period of time (dwell) during each trigger pull to permit the valve **110** to release a sufficient quantity of compressed gas to initiate a full firing cycle of the pneumatic gun. This can be accomplished, for instance, by configuring a contacting surface of the cam actuator **132** with a sufficient surface area to contact the valve actuator **140** for a sufficient length of time during each trigger pull. The geared connection **130** can, for instance, be configured to retain communication between the driving gear(s) **134***a* and the cam gear(s) **131***a* until after the cam actuator **132** has traveled a desired distance across the valve actuator **140**, or until the cam actuator **132** disengages from contact with the valve actuator **140**. The inputs and outputs of the valve **110** can, for instance, be the same as, or similar to, those of the conventional electro-pneumatic paintball gun.

The return mechanism can comprise, for instance, one or more springs **150** and/or one or more magnets (not shown) arranged to cause the cam mechanism **131** to rotate sufficiently after each trigger pull to return to its ready position. For instance, the return mechanism can be a spring assembly **150** configured to pull the cam mechanism **131** around from the actuating position to a start or ready position where the geared cam surface **131***a* reengages with the geared trigger interconnection **134***a*. Alternatively, or additionally, reverse polarity magnets (not shown) can be used to apply a force that encourages the cam assembly **131** to rotate from the firing position back to the ready position.

As shown in FIG. **3**, a mounting plate **55** can be configured to provide a support structure for converting a conventional electro-pneumatic paintball gun into a mechanically-actuated

pneumatic paintball gun. The mounting plate **55** could, for instance, provide mounting structures for attaching a trigger assembly **118** and the valve actuator **40**, along with a modified grip frame **60**, to a body of a conventional electro-pneumatic paintball gun. FIGS. **5-9** provide additional illustrations of cams **130**, **134**, **136**, a trigger **120**, and a grip frame **60**, that could be used in the previous embodiment.

As can be seen from the foregoing description and accompanying drawings, a design incorporating principles of the present inventive concepts can be configured to allow greater control of the dwell time produced by a mechanical pneumatic marker. Specifically, the cam-shaped actuator **132** can be used to provide contact with the valve actuator **140** during a sufficient duration of time to provide the specific dwell time needed to cycle the bolt of a spool valve pneumatic gun design and dump the contents of a compressed gas storage chamber to fire the paintball gun. This design therefore differs from conventional mechanical markers which provide control only over the force used to knock open a firing valve or "poppet valve" to perform the firing operation of the pneumatic gun. Using the traditional poppet valve design, it is difficult, if not impossible, to provide sufficient dwell time to cycle a bolt of a spool valve system, because spool-valve designs require more time (i.e., longer dwell/valve actuation times) to allow the bolt to fully dump the contents of the compressed gas storage chamber.

In one alternative embodiment, oppositely polarized magnets (not shown) could be placed on the surface **132** of the cam **131** and the valve actuator **140**. In this embodiment, the repelling forces between the magnet(s) on the cam **131** and the magnet(s) on the valve actuator **140** could be used to actuate the valve actuator **140** as the cam **131** makes its rotation. This design could therefore eliminate surface to surface contact between the cam **131** and valve actuator **140** to thereby eliminate the friction and wear that would otherwise occur between these two parts.

In another alternative embodiment, the trigger **120** could be configured to actuate a pneumatic piston (not shown) that in turn actuates the valve actuator **140**. In this embodiment, the pneumatic piston (not shown) can either contact the valve actuator **140** directly or can use oppositely polarized magnets (not shown) to create the force to open the valve actuator **140**. The trigger mechanism **118** could, for instance, be configured to actuate a pilot valve (not shown) that controls the operation of the pneumatic piston (not shown), or it could be configured to drive the pneumatic piston directly. This embodiment could thereby eliminate the need for the cam assembly **130** and its associated gearing mechanisms.

FIGS. **10-19** are various schematic illustrations of a pneumatic gun **20** and its components constructed according to another embodiment incorporating principles of the present inventive concepts. FIG. **10** is a somewhat schematic cross-sectional side view of a pneumatic gun **20** having a mechanically-actuated pneumatic valve **110'**, according to another embodiment incorporating features of the present inventive concepts. FIG. **11** is a somewhat schematic cross-sectional exploded view showing the trigger and valve assembly **100**A removed from the pneumatic gun of FIG. **10**, along with its pneumatic connectors **16***a*, **16***b*. FIG. **11**B is a somewhat schematic cross-sectional exploded view showing a trigger and valve assembly **100**B having a pneumatic valve **110"** constructed according to another embodiment of the inventive concepts. FIG. **12** is a somewhat schematic cross-sectional close-up side view of the mechanically-actuated pneumatic valve and trigger assembly **100**A arranged in the pneumatic gun **20** of FIG. **10**, illustrating the mechanical pneumatic valve **110'** in a deactuated position. FIG. **13** is a somewhat schematic cross-sectional close-up side view of the mechanically-actuated pneumatic valve and trigger assembly **100**A of the pneumatic gun **20** of FIG. **10**, illustrating the mechanical pneumatic valve **110'** in an actuated position. FIG. **14** is a somewhat schematic cross-sectional side view of the mechanically-actuated pneumatic valve **110'** of FIG. **12**, illustrating a flow path of compressed gas through the pneumatic valve **110'** in its deactuated (closed) position. FIG. **15** is a somewhat schematic cross-sectional side view of the mechanically-actuated pneumatic valve **110'** of FIG. **12**, illustrating a flow path of compressed gas through the pneumatic valve **110'** in its actuated (open) position.

Referring first to FIGS. **10-15**, a mechanically-actuated pneumatic paintball gun **20** according to embodiments of the present inventive concepts, preferably includes a mechanically-actuated pneumatic valve **110'** or **110"** having a face seal design. The mechanically-actuated pneumatic valve **110'** or **110"** can comprise an input port **113***a* receiving compressed gas from a compressed gas regulator and one or more output ports **113***b*, **113***c*. In operation, compressed gas can be constantly supplied from the input port **113***a* to a first output port **113***b*.

The valve body **110***a* can be formed, for instance, in two sections, including a top section **111***a* and a bottom section **111***b*. In one embodiment **100**A, illustrated in FIGS. **11**, **18** and **18**A, the valve assembly **110'** includes a valve body **110***a* in which the top section **111***a* can include the input port **113***a* and one of the output ports **113***b*. The bottom valve section **111***b* can include a second output port **113***c*. In another embodiment **100**B, illustrated in FIGS. **11**A, **18**B and **18**C, however, the top section **111***a* of the valve assembly **110"** can include the input port **113***a* and multiple output ports **113***b*, **113***c*. Other configurations and arrangements of the valve ports within the sections of the valve body are also possible.

A face seal **112** can be arranged in the valve body **110***a* and be configured to move between two positions. In a first position, the face seal **112** can permit compressed gas from the input port **113***a* to be supplied to a second output port **113***c* through an internal supply port **113***e*. In a second position, the face seal **112** can block an internal supply port **113***e* and vent compressed gas from the second output port **113***c* through an exhaust port **113***d* in the valve body **110***a*.

An actuator **140**, such as a pin or pin-shaped actuator, for instance, can be configured and arranged to move the face seal **112** from the first position to the second position, for instance, during a trigger pull. A contact surface **132** of the trigger **120** can be configured to contact the valve actuator **140** and move it from the first position to the second position. When the trigger **120** is released, a spring **150** (or other return mechanism, such as opposite polarity magnets, etc.) can cause the trigger to return to its resting position, awaiting another trigger pull. In the case of a spring **150**, one end of the spring **150** can be connected to a connecting point **122** of the trigger **120** and another end can be connected to the grip frame **60**.

The pneumatic connectors **116***a*, **116***b* can be connected to appropriate respective ports **28***a*, **28***b* in the pneumatic gun **20**. A first pneumatic connector **116***a* can be connected to a first port **28***a* to communicate compressed gas between the second output port **113***c* of the valve **110'** or **110"** and the first port **28***a*, which communicates with a forward end of a pneumatic mechanism **30** arranged in the paintball gun **20**. A second pneumatic connector **116***b* can be connected to a second port **28***b* to communicate compressed gas from the first output port **113***b* to a rearward end of the pneumatic mechanism **30**.

Referring now specifically to FIGS. **14** and **15**, when the mechanical, pneumatic valve **110'** (or **110"**) is deactuated

(i.e., in its normal, resting state), the valve **110'** is closed, permitting compressed gas coming into the valve **110'** through the input port **113***a* from the regulator to be supplied through the internal supply port **113***e* to the second output port **113***c*. Compressed gas from the regulator is also constantly supplied to the first output port **113***b*. When the mechanical, pneumatic valve **110'** (or **110"**) is actuated (i.e., by upward movement of the valve actuator **140**), the face seal **112** is seated up against the internal supply port **113***e* sidewalls to prevent gas from the input port **113***a* from entering the internal valve chambers and being communicated to the second output port **113***c*. At the same time, the exhaust port **113***d* is opened by movement of the face seal **112** away from the outlet sidewalls and compressed gas communicating with the second output port **131***c* is vented from the valve **110'** through the output port **113***d*. An end **144** of the valve actuator **140** can, for instance, be arranged within a receptacle of the face seal **112**, or can be configured to contact the face seal **112** or another component connected to the face seal **112** to move the face seal **112** between its first and second positions.

Referring to FIGS. **14** and **15**, in this embodiment, the distance the face seal **112** travels from its first position to its second position can be less than approximately 0.015 inches. A preferred travel distance for the face seal **112** is less than about 0.0075 inches, but can range, for instance, from approximately between 0.005 inches and 0.025 inches. By maintaining a small face seal travel distance, only a short stroke trigger pull is required, and the force required to open the mechanically-actuated pneumatic valve is minimal. This in turn helps minimize the possibility of either misfiring or misfeeding the pneumatic gun. In addition, the use of a face seal valve design can eliminate the need for lubricating the valve's operating mechanism and thereby substantially reduce maintenance issues associated with the pneumatic valve.

FIGS. **16**-**17**E are somewhat schematic cross-sectional side views illustrating pneumatic components of a pneumatic gun **20** according to additional principles of the present inventive concepts. Referring now to FIGS. **10**-**17**E, in one pneumatic gun embodiment, compressed gas having a selected pressure can be supplied to the gun **20** from a compressed gas regulator **40** that receives compressed gas from a supply connected to the pneumatic gun **20** through a connector **42**. In this embodiment, the compressed gas from the regulator **40** is supplied to a mechanical, pneumatic valve **110'** or **110"**, which in turn supplies a constant supply (Constant Supply) of compressed gas to a storage chamber **26** of the pneumatic gun **20** through the rearward port **28***b*.

As shown in FIG. **17**A, the pneumatic valve **110'** or **110"** can further be configured to supply compressed gas of the selected pressure from the compressed gas regulator to a first (e.g., forward facing) surface of a spool-valve piston **30** through the second output port **113***c* and the forward gun port **28***a* when the face seal **112** is arranged in its first, deactuated position. The compressed gas acting on the first surface of the spool-valve piston **30** can overcome a pneumatic or spring force acting on a second (e.g., rearward facing) surface of the spool-valve piston **30**. In this state, the pneumatic gun **20** is charged and ready to fire when a projectile **21** is arranged in the loading chamber (breech) at the front of the bolt **30***a*.

In this embodiment, the spool-valve piston **30** can comprise a bolt **30***a* and a firing valve **30***c*. The first surface can be a forward-facing surface and the pneumatic force acting on the first surface can hold the bolt in a rearward position against a pneumatic force from the compressed gas storage chamber acting on the second, rearward-facing piston surface area. The second surface area is therefore preferably smaller than the first surface area.

A trigger **120** can be configured with a contact surface or actuator **132** arranged to contact a valve actuator **140** or valve pin of the pneumatic valve **110'** or **110"**. When the trigger **120** is pulled, its contact surface **132** contacts the valve actuator or pin **140** to move the face seal **112** from its first position to its second position. In the second position, compressed gas is prevented from being supplied to the second output port **113***c* from the compressed gas regulator **40**, and gas from the second output port **113***c* is instead vented through an exhaust port **113***d* in the valve body **110***a*.

When the second output port **113***c* communicates with the forward piston surface and the valve **1110'** or **1110"** is opened, gas is vented from an area communicating with the forward piston surface and a force on the second, rearward piston surface drives the bolt **30** forward. The bolt **30** is thereby moved into its forward, firing position (FIG. **17**C) and the firing valve **30***c* opens to permit compressed gas from the compressed gas storage chamber **26** to vent through the firing valve **30***c* and through ports (not shown) arranged in the bolt **30***a* to launch a projectile **21** from the gun **20**.

Once the trigger **120** is released, pneumatic pressure (or spring or other biasing force) returns the valve seal **112** to its first position (i.e., closed) and compressed gas is again directed to the forward surface area of the pneumatic piston **30**. The force on the forward surface area is preferably larger than a force acting on a rearward surface area (i.e., from the constant supply of compressed gas in the compressed gas storage area). The bolt **30***a* is thereby moved rearward, allowing a paintball or other projectile **21** to drop into the loading area through a loading or feed tube **24**, and the firing valve **30***c* is closed. The gun **20** is then charged and loaded and ready for another firing cycle.

FIGS. **18** and **18**A are a somewhat schematic perspective and exploded perspective view of a mechanical pneumatic valve **110'** for use in the pneumatic gun **20** of FIG. **10**. Referring to FIGS. **18** and **18**A, the valve body **110***a*, can include two sections **1111***a* and **111***b* secured together by screws **117** threaded through openings **117***a*, **117***b* in the two sections of the valve body **110***a*. The face seal **112** can be arranged at the center of a disc **114** having ports **114***a* arranged therethrough to permit compressed gas to flow freely between opposing sides of the disc **114**. The disc **114** can help keep the face seal **112** centered in the valve body **110***a* as it moves up and down.

FIGS. **18**B and **18**C are a somewhat schematic perspective and exploded perspective view of a mechanical pneumatic valve **110"** for use in the pneumatic gun **20** of FIG. **10**, according to another embodiment of the present inventive concepts. Referring to FIGS. **18**B and **18**C, the valve body **110***a* can again include two sections **111***a* and **111***b* secured together by screws **117** threaded through openings **117***a*, **117***b* in the two sections of the valve body **110***a* and a clamp plate **119**. Unlike the previous embodiment, however, the input port **113***a* and two exhaust ports **113***b* and **113***c* are arranged in the upper valve section **111***a*. In both embodiments, a third exhaust port **113***d* can be arranged in the lower valve section **111***b*.

As further illustrated in FIG. **18**C, the valve **110"** can include a clamp plate **119**, an o-ring **118***a*, and a backup ring **118**. The clamp plate **119** helps secure the valve sections **111***a* and **111***b* together. The backup ring **118** and o-ring **118***a* seal the internal valve chamber housing the disc **114**.

FIG. **19** is a somewhat schematic perspective view of a trigger **120** for use in the pneumatic gun **20** of FIG. **10**. Referring to FIGS. **10** and **19**, the trigger **120** can be arranged

in a grip **60** of a paintball gun **20**, such that it can rotate a predetermined distance about an anchor point **124**. The rotation angle is preferably sufficient to enable a contact surface **132** of the trigger to contact and move a valve actuator **140** a sufficient distance to open the valve **110'** or **110"** and activate a firing sequence of the pneumatic gun **20**. It should be noted that the terms "open" and "closed" for the pneumatic valve are relative terms and could be used interchangeably to refer to the respective positions of the valve during operation.

Having described and illustrated principles of the present inventive concepts in various preferred embodiments thereof, it should be apparent that the inventive concepts can be modified in arrangement and detail without departing from such principles.

What is claimed is:

1. A mechanical trigger assembly for a pneumatic gun, comprising:

a trigger frame comprising a trigger connected to the trigger frame;

an actuator mechanically coupled to or formed integral with the trigger such that activation of the trigger causes movement of the actuator, and wherein movement of the actuator is configured to mechanically actuate a valve actuator of a mechanical pneumatic valve when the trigger assembly is operatively arranged in a pneumatic gun;

wherein actuation of the valve actuator is configured to move a face seal away from a contact surface of the mechanical pneumatic valve where the face seal abuts against the mechanical pneumatic valve, without the face seal sliding along the contact surface, to actuate the mechanical pneumatic valve and initiate a firing operation of the pneumatic gun.

2. A trigger assembly according to claim **1**, wherein the actuator comprises a contact surface of the trigger configured to contact the valve actuator.

3. A trigger assembly according to claim **2**, wherein the valve actuator is a pin or pin-shaped actuator arranged to contact the face seal of the pneumatic valve through an opening in a body of the mechanical pneumatic valve.

4. A trigger assembly according to claim **2**, wherein the trigger comprises an extension that extends substantially horizontally away from the trigger, and wherein the actuator is arranged on an end of the extension, said trigger being hingedly connected to the trigger frame to permit rotational movement of the trigger with respect to the trigger frame.

5. A trigger assembly according to claim **4**, further comprising a biasing mechanism configured to supply a biasing force to bias the trigger in a first position, wherein actuator does not contact the valve actuator in the first position.

6. A trigger assembly according to claim **1**, wherein the face seal comprises a circular disk having an outer portion and a central portion, wherein the outer portion aligns the face seal within a body of the mechanical pneumatic valve, and wherein the central portion comprises a sealing member configured to selectively block either an internal supply port or an exhaust port of the mechanical pneumatic valve.

7. A trigger assembly according to claim **1**, wherein the valve actuator comprises an actuator head arranged in the trigger frame so as to be contacted by the trigger actuator when the trigger actuator reaches a second position.

8. A trigger assembly according to claim **7**, wherein the valve actuator further comprises a pin or pin-shaped actuator having a first end arranged in the actuator head and a second end extending through an opening in a body of the mechanical pneumatic valve, wherein said second end is configured to open the face seal of the mechanical pneumatic valve when the valve actuator is moved to a second position.

9. A trigger assembly according to claim **8**, wherein the face seal is permitted to close when the valve actuator is in a first position, and wherein a pneumatic force applied to the face seal provides the only force used to reset the trigger to a first position.

10. A trigger assembly according to claim **1**, wherein the face seal of the mechanical pneumatic valve comprises a disk shape having a centrally located sealing member, wherein the sealing member is configured to block an exhaust port of the mechanical pneumatic valve to supply compressed gas to a forward surface area of a pneumatic piston in the pneumatic gun when the mechanical pneumatic valve is in a deactuated state, and wherein the sealing member is configured to move away from the exhaust port to vent compressed gas away from the forward surface area of the pneumatic piston when the mechanical pneumatic valve is in an actuated state.

11. A trigger assembly according to claim **10**, wherein said pneumatic gun is configured to receive a supply of compressed gas from a compressed gas source into a compressed gas storage area and wherein the compressed gas in the compressed gas storage area is configured to act on a second surface area of the pneumatic piston, and wherein a force acting on the second surface area of the pneumatic piston is configured to move the piston forward when the compressed gas is vented away from the forward surface area.

12. A trigger assembly according to claim **1**, wherein the valve actuator comprises a pin-shaped body having at least three separate diameters, wherein a first diameter is configured to fit through an opening in a body of the mechanical pneumatic valve to permit contact between the valve actuator and the face seal, wherein a second diameter is configured to align the valve actuator within a receptacle in the body of the mechanical pneumatic valve, and wherein a third diameter is larger than a diameter of the receptacle.

13. A trigger assembly for a pneumatic gun having a spool-type pneumatic assembly, said trigger assembly comprising:

a trigger configured to be actuated by a user of the pneumatic gun through a pulling motion;

an actuator mechanically connected to or formed integral with the trigger such that the pulling motion of the trigger causes movement of the actuator;

an actuating surface arranged on the actuator and configured to mechanically actuate a valve actuator of the pneumatic gun when the trigger assembly is operatively arranged in the pneumatic gun, and wherein actuation of the valve actuator of the pneumatic gun initiates a firing operation of the pneumatic gun by mechanically moving a face seal of a pneumatic valve away from a contact surface of the pneumatic valve, without the face seal sliding along the contact surface.

14. A trigger assembly according to claim **13**, wherein the valve actuator is a pin-shaped actuator arranged through an opening in a body of the pneumatic valve, and wherein a second end of the pin-shaped actuator comprises a contact surface configured to physically contact the face seal of the pneumatic valve to actuate the pneumatic valve by unseating the face seal from abutting against the contact surface which surrounds an exhaust port of the pneumatic valve.

15. A trigger assembly according to claim **14**, wherein the valve actuator further comprises an actuator head arranged in the trigger assembly so as to be contacted by the trigger when the trigger is actuated, said actuator head having a first end of the pin-shaped actuator arranged therein or mechanically coupled thereto.

16. A trigger assembly according to claim **14**, wherein actuation of the pneumatic valve moves a centrally located sealing member of the face seal away from the exhaust port to

vent compressed gas through the pneumatic valve away from a forward piston surface area of a pneumatic piston in the pneumatic gun to permit forward movement of the pneumatic piston.

17. A trigger assembly according to claim **16**, wherein the trigger is configured to travel through a predetermined rotational angle during the trigger pull, and wherein the predetermined rotational angle is sufficient to permit contact between the contact surface of the pin-shaped actuator and the face seal to move the face seal a sufficient distance to effectively perform the firing operation of the pneumatic gun.

18. A mechanically-actuated pneumatic gun comprising:

a trigger hingedly arranged in a trigger frame;

a pneumatic valve comprising a face seal and further comprising a valve actuator configured to physically contact and move the face seal away from but not along an abutting contact surface to actuate the pneumatic valve; and

a trigger actuator arranged in communication with or integral with the trigger and configured to physically move the valve actuator a sufficient distance during the trigger pull to actuate the pneumatic valve and perform a firing operation of the pneumatic gun.

19. A pneumatic gun according to claim **18**, said pneumatic gun comprising:

a pneumatic piston having a first surface area and a second surface area;

a compressed gas storage area configured to house a quantity of compressed gas in communication with the second surface area;

wherein during operation of the pneumatic gun, the first surface area receives a supply of compressed gas from the pneumatic valve through an area between an internal supply port and the face seal when the valve is in a deactuated position, and wherein the supply of compressed gas to the first surface area is cut off by abutting the face seal against the contact surface arranged on a sidewall of the internal supply port, and wherein the compressed gas previously supplied to the first surface area is vented through an area between the face seal and an exhaust port in the pneumatic valve when the valve is in an actuated position.

20. A pneumatic gun according to claim **19**, wherein venting the compressed gas from the first surface area permits the pneumatic piston to move forward and perform a firing operation of the pneumatic gun.

* * * * *